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CNC CHARLESTON
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PERMIT APPLICATION RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION SOLID WASTE MANAGEMENT UNIT 166 (SWMU 166) WITH TRANSMITTAL CNC CHARLESTON SC

1/29/2002

CH2M HILL

SWMU 166 Zone K

PERMIT APPLICATION - UNDERGROUND INJECTION CONTROL

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CH2MHILL
Constructors, Inc

January 29, 2002

158814.ZK.EX.07

Mr. Todd Adams
Permit Coordinator
South Carolina Department of Health and Environmental Control
Bureau of Water
Water Monitoring Assessment & Protection Division
Groundwater Management Section
2600 Bull Street
Columbia, SC 29201

Subject: Permit Application – Underground Injection Control
RCRA Facility Investigation
Solid Waste Management Unit (SWMU) 166
Charleston Naval Complex (CNC), North Charleston, South Carolina

Dear Mr. Adams:

On the behalf of the U.S. Navy Southern Division Naval Facilities Engineering Command, CH2M-Jones has prepared a Underground Injection Control Permit application (Form 1) and attachments A through K for a Pilot Study at SWMU 166 at the Charleston Naval Complex in North Charleston, South Carolina. The Pilot Study will involve *in-situ* chemical reduction, using the Ferox^{SM} process, to treat groundwater contaminated with hexavalent chromium.

The chemical reduction process to be implemented at SWMU 166 involves subsurface injection of zero-valent iron (ZVI). The reaction mechanism for the reduction of TCE begins with the corrosion of ZVI as it comes into contact with a water molecule. The products of corrosion are ferrous iron (Fe^{+2}), hydrogen gas (H^2), and a hydroxyl ion (OH^-). The hydrogen gas produced combines with the halogenated organic compound (e.g., TCE) on the surface of a catalyst (iron powder, naturally-occurring electron mediator, or unidentified constituents in the soil organic matter) whereby the contaminant is dehalogenated.

The technical approach to implementing the IM is provided in the *Interim Measure Work Plan, SWMU 166, Zone K* (January 2002). This work plan is currently under review with the SCDHEC Corrective Action Engineering Section, Division of Waste Management, Bureau of Land and Waste Management and the Environmental Protection Agency.

If you have any questions, comments or require additional information please do not hesitate to contact us.

Sincerely,

CH2M HILL

Sam Naik, CH2M-Hill

for Tom Beisel, P.G.
Project Manager
(770) 604-9182 ext. 255

cc: Tony Hunt, P.E./SOUTHDIV
Dean Willamson, P.E./CH2M HILL, GNV
Tom Beisel, P.G./CH2M HILL, ATL

Form 1 UIC	D H E C Underground Injection Control Permit Application Ground-Water Protection Division (Collected under the Authority of Title 48 Chapter 1 of the 1976 South Carolina Code of Laws)	I. EPA ID NUMBER		T/A	C
		U			

Read attached instructions before starting.

For Offical Use Only

Application Approved month	day	year	Date Received month	day	year	Permit/Well Number

Comments

II. Facility Name and Address	III. Owner/Operator and Address
Facility Name Charleston Naval Complex North Charleston, South Carolina	Owner/Operator Name United States Navy, Southern Div. ATTN: Tony Hunt BRAC Environmental Coordinator
Street Address Near the intersection of Avenue B and Fifth Street, in the vicinity of Building 2821 at the former Naval Annex, Charleston Naval Complex, North Charleston, SC.	Street Address North Charleston, SC 29406
City State Zip Code North Charleston, SC 29406	City State Zip Code

IV. Ownership Status (Mark "x")

☒ A. Federal ☐ B. State ☐ C. Private ☐ D. Public ☐ E. Other (Explain)

V. SIC Codes

3731

VI. Well Status (Mark "x")

☐ A. Operating Date Started month day year ☐ B. Modification/Conversion ☐ C. Proposed

VII. Type of Permit Requested - Class and Type of Well (see reverse)

A. Class(es) enter code(s)	B. Type(s) enter code(s)	C. If class is "other" or type is code "x", explain	D. Number of Wells per type

VIII. Location of Wells or Approximate Center of field or Project

C	A. Latitude			B. Longitude		
	Deg	Min	Sec	Deg	Min	Sec
I	32	53	48	80	01	15

IX. Attachments

Complete the following questions on a separate sheet(s) and number accordingly; see instructions for Classes II, III, and V, complete and submit on a separate sheet(s) attachments A-H as applicable. Attach maps where required. List attachments by letter which are applicable and include with your application.

X. Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of a fine and imprisonment.

A. Name and Title (Type or Print)	B. Phone No.
Robert A. Hargett Jr. Remediation Project Manager	(843) 820-5551
C. Signature	D. Date Signed
Robert A Hargett Jr	29 January 2002

DHEC 2002 (09/1997)

Attachments A-K to Form 1 - Underground Injection Control

Attachment A: Activity for Review

Submit a brief description of the activities to be conducted that require a UIC permit.

CH2M-Jones is requesting an Underground Injection Control (UIC) Permit for the injection of Zero-Valent Iron (ZVI) into the shallow aquifer system at Zone K (the former Naval Annex of CNC), SWMU 166, Charleston Naval Complex (CNC), as part of a RCRA Interim Measure (IM). The purpose of the injection is to treat chlorinated solvents (primarily trichloroethene (TCE)) in groundwater. CH2M-Jones has contracted with ARS Technologies, Inc., of New Brunswick, NJ to implement the pilot study for *in-situ* treatment of chlorinated solvent contamination at one of the target treatment areas (TTAs) named TTA4 at SWMU 166. Seven other TTAs at SWMU 166 will be treated at a later stage after evaluation of the results from the pilot study tests. An addendum or a separate UIC permit request will be made for injection activities at these seven TTAs.

ARS will implement their proprietary Ferox^{SM} process at the site. A similar injection process by the same vendor is being currently implemented at SWMU 70 at CNC.

The process involves installation of boreholes. The boreholes are used as access points for the ARS equipment that will be used to pneumatically fracture the subsurface formation and deliver ZVI into the fractures. A total of 3 boreholes will be installed at the pilot study area (shown as Region 1 and Region 2 of TTA 4 in Figure 1) will be installed at the project site as part of this pilot study; the holes will be held open with temporary well casing.

The process system consists of a skid-mounted fracture module complete with an injection control manifold and a digital data logger used to monitor various operational parameters. Due to the large quantity of compressed gas needed for fracturing and Ferox^{SM} injections within SWMU 166, ARS will use pressurized nitrogen as the fracturing fluid. A series of bulk nitrogen "tube" trailers will be mobilized to the site for this operation. Figure 2 shows a schematic of the injection process layout.

The compressed nitrogen is routed through the fracture modules' control manifold and is connected by a high-pressure hose to a proprietary injector. Once the necessary equipment is in place, and all field personnel are instructed on safety aspects of the activities, the outer drive casing will be raised, exposing the injector nozzle to the formation. The packers will be inflated and the formation will be fractured. Fracturing will consist of applying pressurized nitrogen for approximately fifteen seconds within a 20 to 30-inch interval isolated by the use of a double pneumatic straddle packer assembly (the actual injection interval will be finalized in the field).

During each injection, the following system operational parameters will be observed and collected:

- Downhole injection initiation and maintenance pressures;
- Injection pressure influence at surrounding monitoring points, if available; and
- Ground surface heave adjacent to, and in the vicinity of, the injection point.

Other visual observations during injection will also be recorded.

Ferox℠ injections will be performed immediately following Pneumatic Fracturing at each injection interval within the borehole. The iron powder/water slurry will be injected into the subsurface utilizing a nitrogen gas stream integrated with a high-pressure, high-flow injection manifold. The manifold system will provide accurate injection pressures, which will enable ARS to achieve the optimal iron powder dispersion.

Each borehole will be addressed starting at the deepest interval and working upward. This will ensure that borehole stability is maintained. When the targeted dosage of iron is emplaced into the formation, the packers will be deflated, and the nozzle assembly will be raised to the next injection location.

During the pilot test, approximately 6,000 pounds of ZVI will be injected into the subsurface saturated zone.

Assuming that each injection has a radial influence of approximately 20 ft, 3 injection boreholes are needed to target the entire area of TTA4 . The location and number of injection points may change depending on presence of utilities and building structures. Each borehole in Region 1 of TTA4 will be used for approximately five different injection intervals, ranging in depth from approximately 20 to 35 ft-bgs; and two injections are proposed in the borehole at Region 2 of TTA4 from approximately 24 to 30 ft bgs.

An extensive groundwater monitoring program is planned before and after injection to monitor changes in contaminant concentrations.

Attachment B: <u>Well Construction Details</u>

Submit schematic or other appropriate drawings of the surface and subsurface construction details of the recovery and injection wells.

Please see attached Figures 2 and 3 for a schematic of the pneumatic fracturing and injection wells. Using the hydraulic push and hammering capabilities of the Geoprobe (or similar push-brand) drill rig, a 4.5-inch OD threaded HW casing will be advanced to depth (approximately 28 ft bls). This casing will serve as a conduit for the ARS equipment. The casing is emplaced to prevent borehole collapse. The casing will be lifted out of the ground after all the ZVI has been delivered through the borehole.

The open-borehole (i.e., the area where the casing has been lifted from and packers have been inflated), will serve as an injection point. As only temporary well casing will be installed, a well construction detail figure has not been prepared.

Attachment C: Operating Data

Submit the following proposed operating data for each injection well:

1) *Average and maximum daily rate and volume of fluid to be injected. In addition, indicate the average and maximum daily rate and volume of fluid to be withdrawn from each recovery well. Verification of the aquifer's hydraulic ability to produce and accept the quantities proposed should be presented.*

The injected fluid consists of iron powder slurry mixed with tap water. Approximately one gallon of water is slurried per kilogram of ZVI. The average and maximum amount of iron injected on a daily basis is 2,000 and 3,500 pounds, respectively. The average and maximum daily volumes of water to be injected with the iron are 900 and 1,600 gallons respectively. The average and maximum number of injection events (each with a duration of approximately one-half our each.) is four to seven per day. The aquifer has capacity to accept the proposed injection volumes.

2) *Average and maximum injection pressure.*

Initiation pressures for pneumatic fracturing will be between 110 and 180 psi. The initiation phase of the pneumatic fracturing process has a duration of less than 15 seconds. The sustaining pressure of the injection will be between 50 and 100 psi. The sustaining pressure component of the ZVI delivery procedure will last from 15 to 30 minutes.

3) *Pumping schedule*

It is expected that all three injection events will occur in one or two days.

4) *Proposed ranges in the concentration of all contaminant constituents within the injection fluid. Include comprehensive ground-water quality data from a "worst case" well sample.*

No wastes or contaminated water will be injected or generated during this work.

5) *Length of time the project is expected to require injection to complete remediation (to ensure the effective dates of the permit will allow sufficient time to complete the project).*

The pilot test injection will be performed in early-to-mid February 2002. The total number of days scheduled for injection during this time period is 4. Based on results of the pilot test, the injection parameters may be streamlined. A design addendum will be performed by ARS and provided to explain any variations to the injection parameters used during the pilot test. This information will be provided to SCDHEC as part of an addendum to the SWMU 166 IM Work Plan. Later injections at the remaining TTAs at SWMU 166 are expected to be accomplished in the April 2002 through August 2002 time frame.

Attachment D: Monitoring Program

Discuss the planned monitoring program in detail:

1) *Include a discussion of monitoring devices, sampling frequency (sufficient to verify treatment system efficiency), sampling protocol, sampling location, parameters to be analyzed, and proposed method(s) of analysis.*

2) *This plan should indicate how, through monitoring, the proposed contaminant levels in the injectate will be verified.*

3) *This plan should also clearly illustrate exactly how hydraulic control of the contaminant plume (and injectate, where relevant) will be verified through monitoring (i.e., piezometers, quality analyses, etc.).*

As previously indicated, no wastes or contaminated water will be injected or generated during this work. ZVI, water, and nitrogen gas will be injected and result in only localized mounding of groundwater. As the injection will occur over a specified period, and then only 8-10 hours per day, the effects of mounding will be temporary. Normal groundwater elevations will become established shortly after injection of reagent has ceased. The baseline aquifer conditions (contaminant concentrations in groundwater and water levels) will be determined prior to injection by sampling selected monitor wells at the site. The effectiveness of the chemical reduction process on improving groundwater quality will be monitored 30 to 60 days after injection.

Attachment E: Existing or Pending State/Federal Permits

List the program and permit number of any existing State or Federal permits for the facility (i.e., NPDES, RCRA, UST, etc.).

Currently, the CNC and its Annex are considered a large quantity generator under the Resource Conservation and Recovery Act. A revision to the Part B permit application to reflect closure of two treatment, storage, and disposal facilities was submitted in September 1997 and subsequently approved by SCDHEC in August 1998. The Environmental Protection Agency Identification Numbers for the CNC and Annex are SC0 170 022 560 and SC0 000 328 906, respectively.

Attachment F: Description of Business

Give a brief description of the nature of the business of the facility and any immediately adjacent facilities.

Limited tenant operations continue at the CNC following the April 1, 1996 closure of the facility under the Defense Base Closure and Realignment Act. Some parts of SWMU 166 area are currently leased by U.S. Marines for training facilities.

Attachment G: Area of Review

1) *The area of review should be a fixed radius of ¼ mile from the injection well, the outermost injection wells if a wellfield.*

2) *If a fixed radius is not selected, the methods and the calculations used to determine the size of the area of review should be submitted.*

The area of review is presented in Figure 4. Some parts of the one-quarter mile radius fall outside the current boundary of Zone K, CNC.

Attachment H: Maps of Wells and Area of Review

1) *Submit a topographic map of the area extending one mile beyond the project property boundaries. The map should show all ...*

2) *A scaled map should be included which shows the name and/or number and the location of all production, injection, monitoring, abandoned and dry wells within the area of review...*

3) *A potentiometric map of the project site should be submitted which accurately locates all monitoring wells and proposed recovery and injection wells...*

Figure 5 shows the one-mile area of review. The location of solid waste management units (SWMUs) and areas of concern (AOCs) at the CNC are noted on the figure. Numerous groundwater monitoring wells, installed as part of the investigations conducted at Zone K, CNC, are located inside Zone K and a short distance east of Interstate-26 within the area of review.

Potentiometric maps for shallow and deep groundwater are presented in Figures 6 and 7.

Attachment I: Cross Sections/Diagrams

1) *Geologic cross sections indicating the lithology and stratigraphy of the site and the horizontal and vertical extent of the contaminant plume, should be submitted. At least two cross sections, one parallel and one perpendicular to the horizontal groundwater flow direction.*

2) *A schematic diagram, in the form of a cross section, showing the proposed remediation system with the components of flow, (above and below ground) and all associated appurtenances (i.e., stripping tower, piping, wells, etc...).*

Attachment 1 is a figure showing the lithological cross-sections for Zone K.

No permanent structures will be installed as part of this IM. The treatment is an "*in situ*" process which reduces contaminants in the subsurface and does not require installation of any engineered systems or controls, aside from boreholes and temporary well casings, to deliver ZVI into the subsurface. The injection equipment that will be used for delivering chemical reagents into the subsurface is mobile. Figures 2 and 3 show a schematic of the pneumatic fracturing process and injection well layout.

Attachment J: Name and Depth of Underground Sources of Drinking Water

Identify and describe all aquifers which may be affected by the injection.

The ZVI will be injected only into the aquifer system at the CNC, comprised of an unconfined (water table) aquifer system within Quaternary-age interbedded silt, sand and clay deposits, with the underlying Ashley Formation acting as a lower hydrologic bounding unit. This shallow water table is not used as a potable supply in the vicinity.

Depth to groundwater in the Zone K surrounding area is typically 5-7 feet below land surface. Monitor wells are installed in the shallow and deep zones of the water table aquifer at SWMU 166.

The underlying Ashley Formation is comprised of Tertiary–age silts and clays, and will not be affected by the injection of ZVI. The Ashley Formation also acts as an upper confining unit for the Santee Limestone, which is under artesian conditions, and is used as a source of potable water. The Santee Limestone will not be affected by the injection of ZVI.

Because of the heterogeneity of the surface fill and subsurface Quaternary deposits, the hydraulic properties of the shallow (water table) aquifer system vary widely, depending on location and depth. The variable hydraulic gradients and hydraulic conductivity measured in wells result in locally variable estimates of groundwater flow rates and directions.

The localized and regional shallow groundwater flow direction is east towards the Interstate 26 which runs north-south outside the eastern boundary of Zone K.

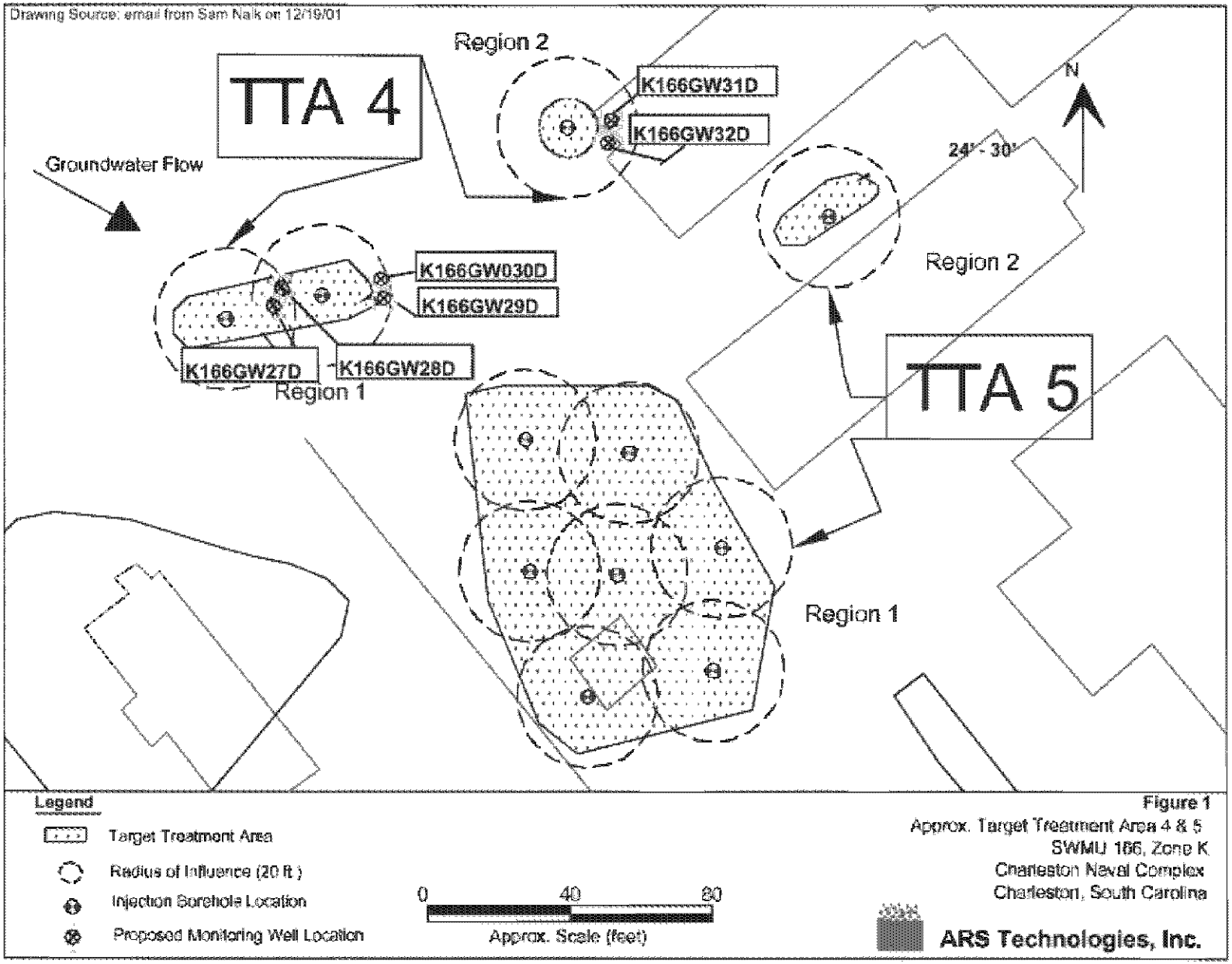
Attachment K: Hydraulic Control

1) *Sufficient supporting data (i.e. time/drawdown data, Theis curves and methods, calculations, etc,), used to determine aquifer characteristics to verify complete hydraulic control over the contaminant plume (and injectate, if proposed injectate quality does not conform to classified groundwater standards) during the injection should be submitted. At a minimum, values should be given for transmissivity, hydraulic conductivity, effective porosity, and specific yield.*

2) *Demonstrate the presence and magnitude of, or absence of, any vertical hydraulic gradient at the site. If a vertical hydraulic gradient exists, show how its direction and magnitude are incorporated in the calculations demonstrating hydraulic control.*

3) *Groundwater flow computer models (especially 2-D map view with potentiometric flow lines) may be utilized and submitted. All calculations should be in English units. All model-derived data and maps should be properly labeled and keyed so as to be clearly understood.*

The injection of ZVI into the subsurface is not anticipated to significantly alter the hydraulic properties of the site.


Drawing Source: email from Sam Naik on 12/19/01
Region 2
TTA 4
K166GW31D
K166GW32D
N
24° - 30°
Groundwater Flow
K166GW030D
K166GW29D
Region 2
K166GW27D
K166GW28D
Region 1
TTA 5
Region 1
Legend
Target Treatment Area
Radius of Influence (20 ft.)
Injection Borehole Location
Proposed Monitoring Well Location
0
40
80
Approx. Scale (feet)
Figure 1
Approx. Target Treatment Area 4 & 5
SWMU 166, Zone K
Charleston Naval Complex
Charleston, South Carolina
ARS Technologies, Inc.

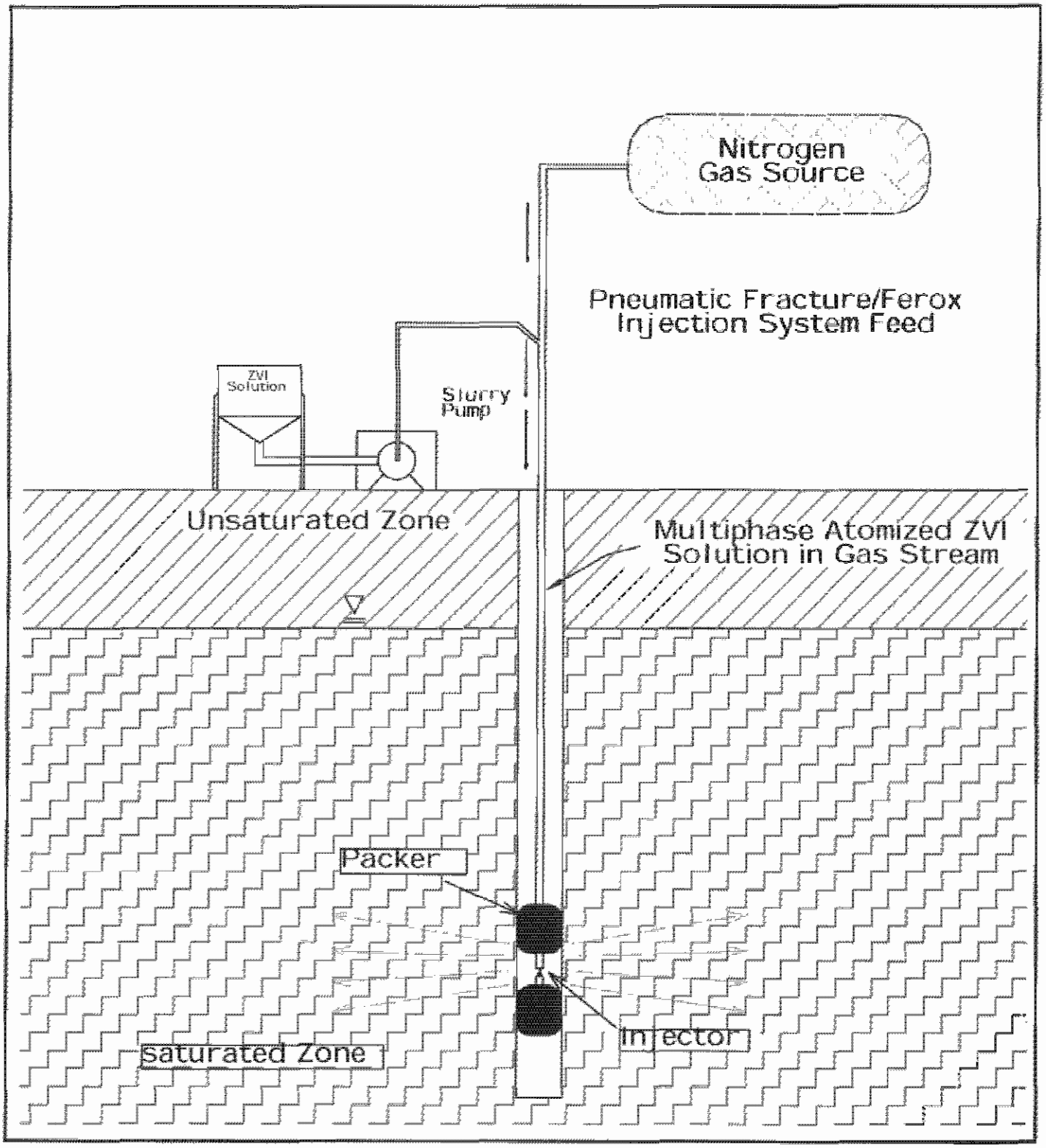
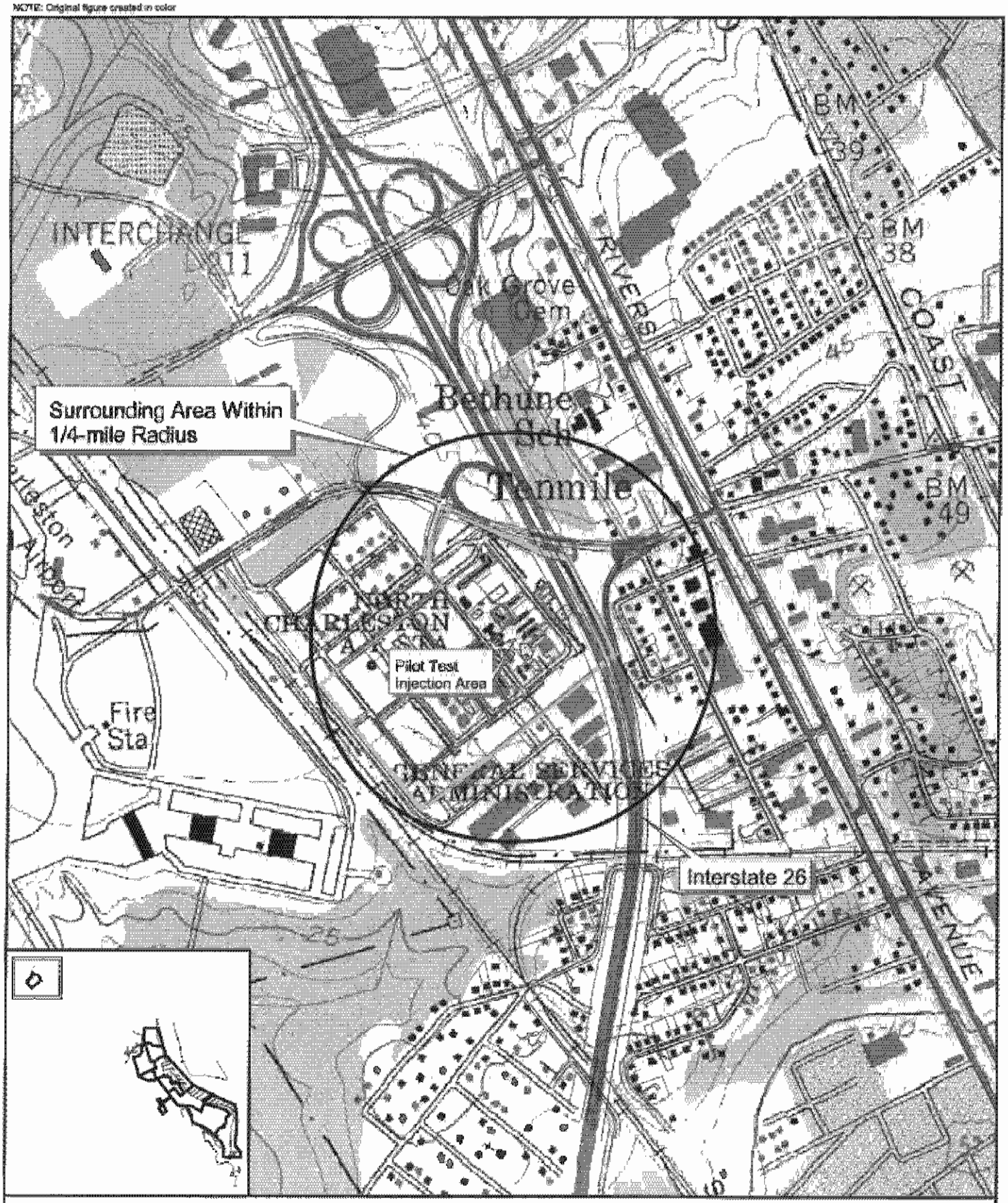


Figure 2 Schematic of ZVI Injection Set up
Source: ARS Technologies, Inc.

NOTE: Original figure created in color



N

0 600 1200 Feet

1 inch = 847 feet

Figure 4
Surrounding Area Within 1/4-Mile Radius
SWMU 166 Pilot Test, Zone K
Charleston Naval Complex

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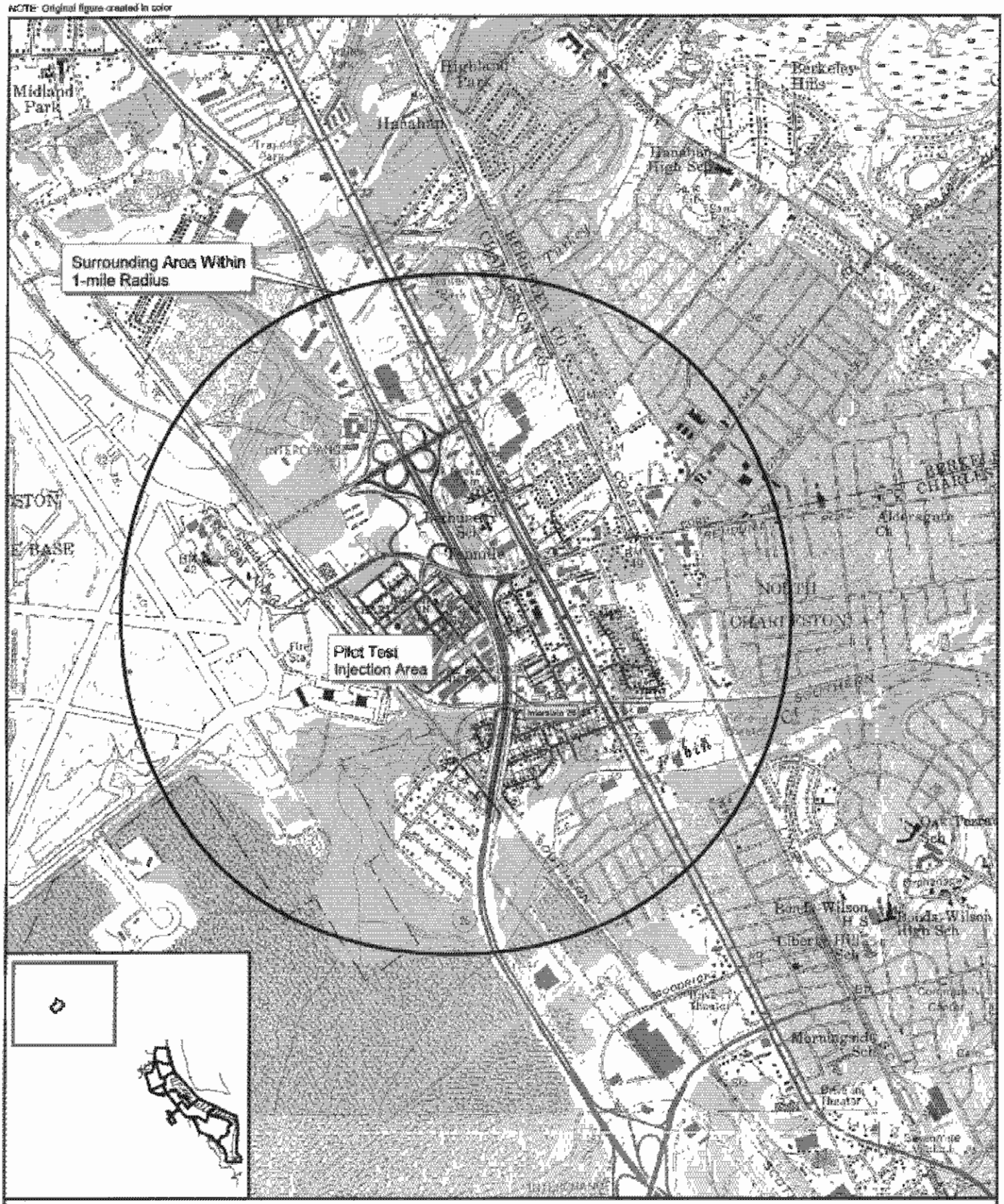
NOTE: Original figure created in color



N

0 2000 4000 Feet

1 inch = 2068 feet

Figure 5
Surrounding Areas Within a 1-mile Radius
SWMU 166 Pilot Test, Zone K
Charleston Naval Complex

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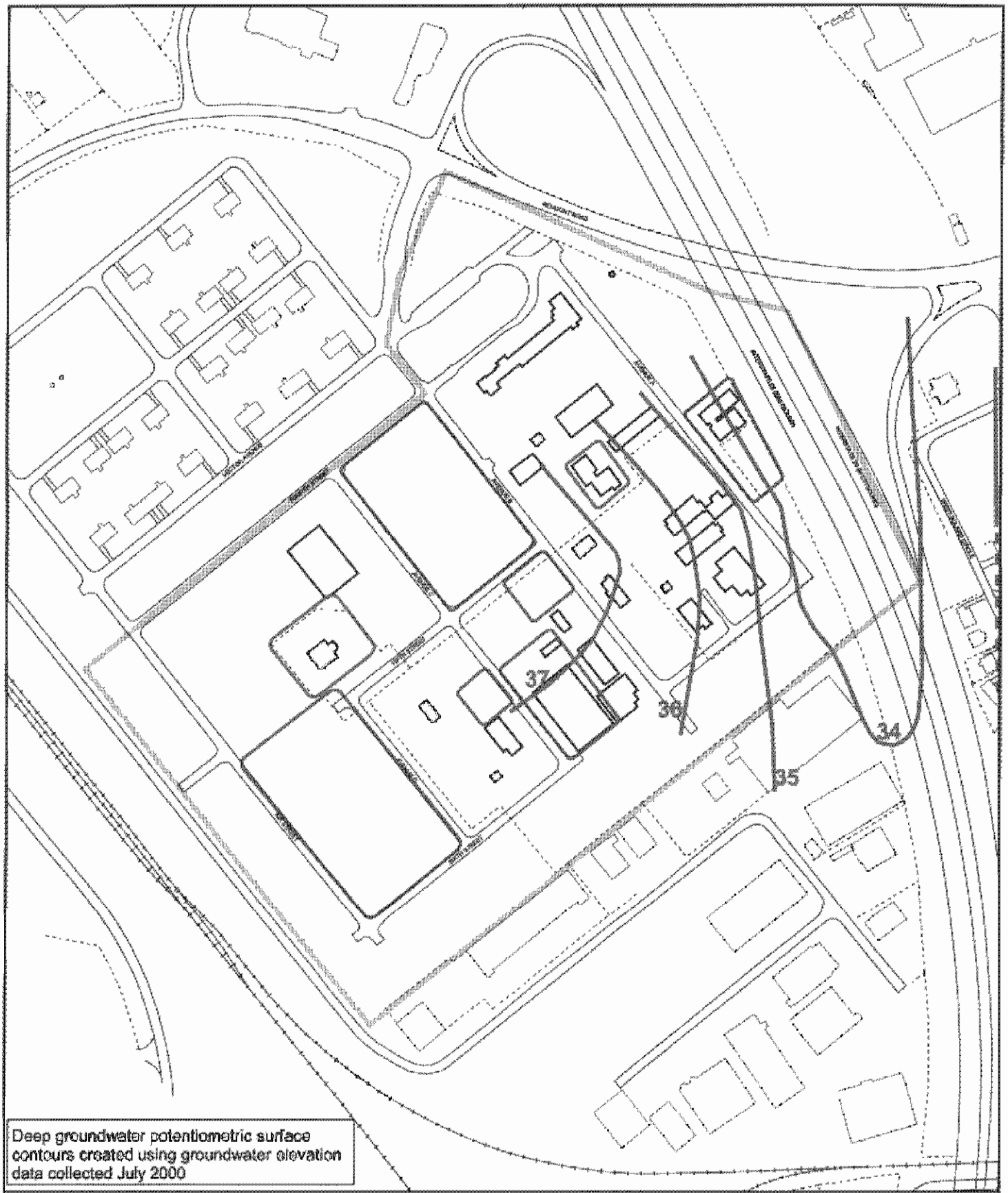

Deep groundwater potentiometric surface contours created using groundwater elevation data collected July 2000

Groundwater Elevation Contour Elevation (ft msl)
Fence
Railroads
Roads
AOC Boundary
SWMU Boundary
Buildings
Zone Boundary
ft msl = elevation in feet referenced to mean sea level

N

0 300 600 Feet

1 inch = 300 feet

Figure 6
Deep Groundwater Potentiometric Map
SWMU 166, Zone K
Charleston Naval Complex

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File Path: G:\IT\gis\Projects\Zone_K\Swmu_166\Apr\swmu166.apr, Date: 11 Jan 2002 7:55, User: NMOUDRY, Figure 2-2 Groundwater Potentiometric Map - Deep

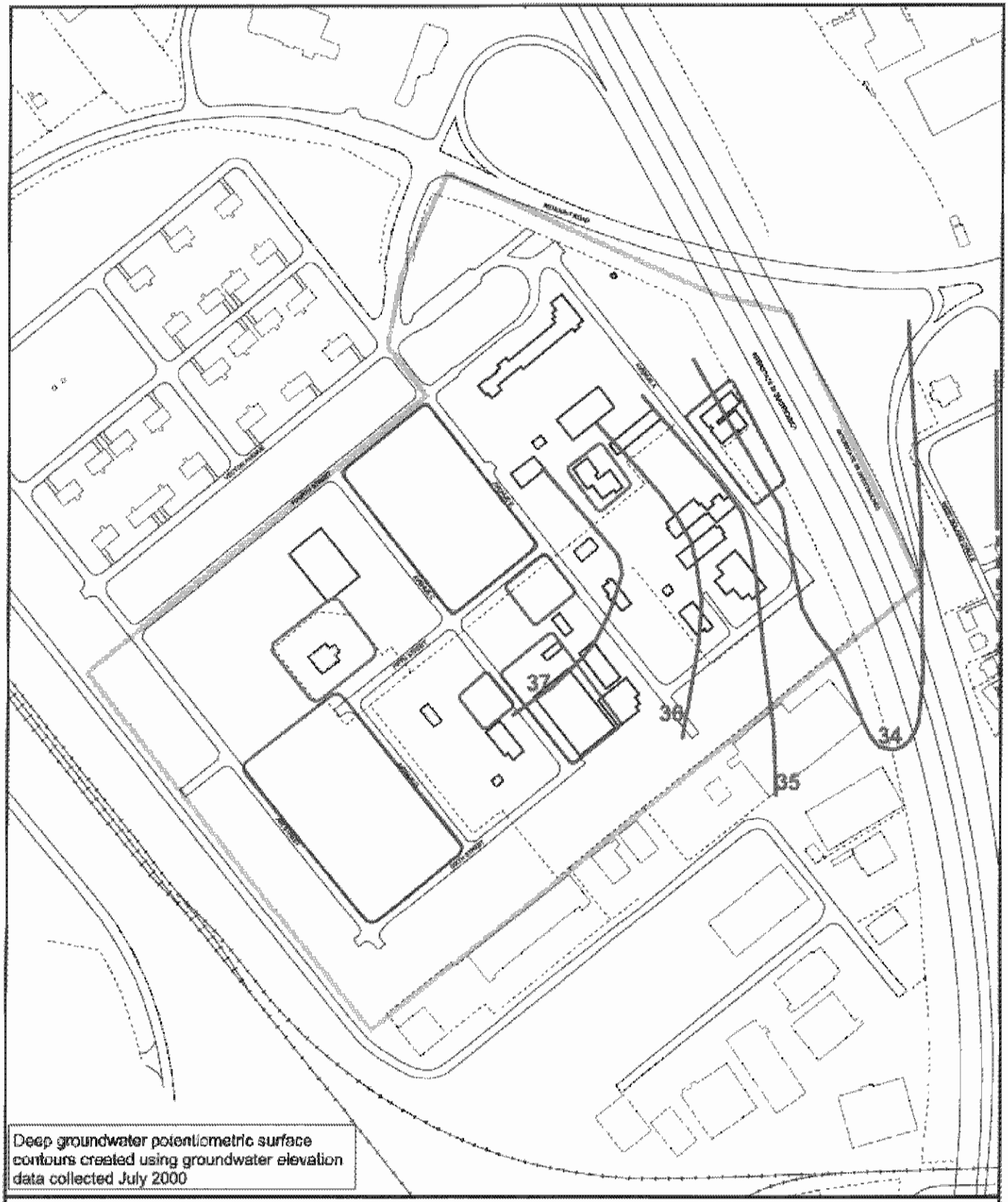

Figure 7
Deep Groundwater Potentiometric Map
SWMU 166, Zone K
Charleston Naval Complex

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File Path: C:\18gis\Projects\Zone_K\Swmu_166\Aprs\swmu166.apr, Date: 11 Jan 2002 7:56, User: NMOUDRY, Figure 2-2 Groundwater Potentiometric Map - Deep